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ABSTRACT

This study investigated how preadolescents and adolescents solve problems involving three temporal dimensions. Specifically examined was the question of whether speed and space information would influence the time judgments of 90 subjects 9, 12, and 15 years of age who solved 16 word problems describing the displacements of two cars. The problems included either relative orders of succession or included one order of succession and the relative duration of the events. Each problem was presented twice: once with speed information and once wih space information. Participants deduced either the relative duration, or the relative beginning or ending times of the events. Duration judgments and order of succession judgments were compared. Findings indicated that older children made more correct judgments than younger children. As predicted, certain problems were facilitated when presented with speed information and were more difficult when presented with space information. The effect was reversed for the other problems. Participants had more difficulty reconstructing the beginning time of an event than deducing the ending time. Results support the notion that specific relations exist between the concepts of time, speed, and space. Time judgments may be hindered if these relations conflict. (RH)

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# Solving Word Problems about Time: The Effect of Speed and Space Information

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## Abstract

Adolescents have difficulty solving word problems about time. This study examined whether speed and space information influence time judgments. Duration judgments and order of succession judgments were compared to each other.

Thirty participants for each group of 9, 12, and 15 year olds solved 16 word problems. The problems described the displacements of two cars. The problems included either relative orders of succession or included one order of succession and the relative duration of the events. Each problem was presented twice: once with speed information and once with space information. Participants deduced either the relative duration, or the relative beginning or ending times of the events.

Older children made more correct judgments than younger children. As predicted, certain problems were facilitated when presented with speed information and were more difficult when presented with space information. The effect was reversed for the other problems. Participants, as expected, had more difficulty reconstructing the beginning time of an event than deducing the ending time. Results support the notion that specific relations exist between the concepts of time, speed, and space. Time judgments may be hindered if these relations conflict.

## Time, Speed, and Space

*The red car goes faster than the black car.*
*The red car leaves before the black car.*
*The two cars stop at the same moment.*

***Does the red car take more or less time than the black car?***

The solution to this nonmetric duration problem is that the red car takes more time than the black car. This study examined how preadolescents and adolescents solve problems involving 3 temporal dimensions. One temporal dimension must be estimated on the basis of the other two. In the example above, the duration is estimated from beginning and ending times. The problem was complicated by the inclusion of speed information. This information is not necessary to the solution of the time problem. Does it nevertheless influence how an adolescent solves the problem?

The assumption tested was that particular relations between the concepts of time, speed, and space are privileged. When activated these relations may hinder time judgments. It is predicted that problems activating the inverse relation *faster - less time* would be easier to solve than problems requiring a deduction of the direct relation *faster - more time* . Conversely, problems that lead to the direct relation *farther - more time* were presumed to be easier to solve than problems that lead to the construction of the inverse relation *farther - less time* .

In addition, the prediction that solving duration problems was of the same difficulty level as solving succession problems was tested.

## Method: Subjects and Procedures

Thirty participants for each group of 9, 12, and 15 year olds solved 16 word problems. Participants read each problem aloud and then answered questions posed by the experimenter. Each problem was presented on an index card. The card remained in front of the participants during questioning thus eliminating potential difficulties in the recall of all the information presented.

Participants were asked to judge either the relative duration, or the relative beginning or ending times of the events. The following problem is an example:

*The red car goes farther than the black car.*
*The two cars leave at the same moment.*
*The red car takes less time than the black car.*

In this example participants judged the relative order of succession: The red car stopped at the same moment, before, or after the black car. Participants also were asked to make judgments on the relative speed or the relative space of the cars. In the example, the red car went at the same speed, faster, or slower than the black car.

## Materials

Participants solved 16 word problems. The problems described the displacements of two cars. The problems included either relative orders of succession or included one order of succession and the relative duration of the events, thus yielding 8 different problems. The combinations were constrained in such a way that either the beginning time or the ending time was simultaneous. Each problem was presented twice: once with speed and once with space information.

The problems can be categorized into 2 groups depending on the correct time responses. The problems are summarized in Table 1 using the following conventions: The first letter corresponds to beginning times or durations and the second letter corresponds to ending times or durations.

| | |
|---|---|
| **Less-Time Problems** | |
| SB: | The two cars leave at the same moment.<br>The red car stops before the black car. |
| SL: | The two cars leave at the same moment.<br>The red car takes less time than the black car. |
| AS: | The red car leaves after the black car.<br>The two cars stop at the same moment. |
| LS: | The red car takes less time than the black car.<br>The two cars stop at the same moment. |
| **More-Time Problems** | |
| SA: | The two cars leave at the same moment.<br>The red car stops after the black car. |
| SM: | The two cars leave at the same moment.<br>The red car takes more time than the black car. |
| BS: | The red car leaves before the black car.<br>The two cars stop at the same moment. |
| MS: | The red car takes more time than the black car.<br>The two cars stop at the same moment. |

S: Same Moment
B: Before
A: After
L: Less Time
M: More Time

Table 1. The 8 Different Time Problems.

## Results

Older children made more correct time responses than younger children. As predicted, the less-time problems were facilitated when presented with speed information and were more difficult when presented with space information. The effect was reversed for the more-time problems. These findings are summarized in Figure 1.

Participants estimated durations just as easily as they estimated successions. For example, estimating that the red car took more or less time was of the same difficulty level than estimating that the red car stopped before or after the black car. Participants, as expected, had more difficulty reconstructing beginning times of events than deducing ending times.

The speed and space responses are divided into two groups whether there is one correct answer or whether there are 3 possible answers to the problems. For the unique answer problems, there were no age effects for the correct responses.

Participants in the 3 age groups made more correct speed judgments than errors. The space judgments were distributed between the correct answer and the equality error (see Table 2). For the ambiguous problems, participants seldom recognized the three possible answers.

# Effect of Speed and Space on Correct Time Responses

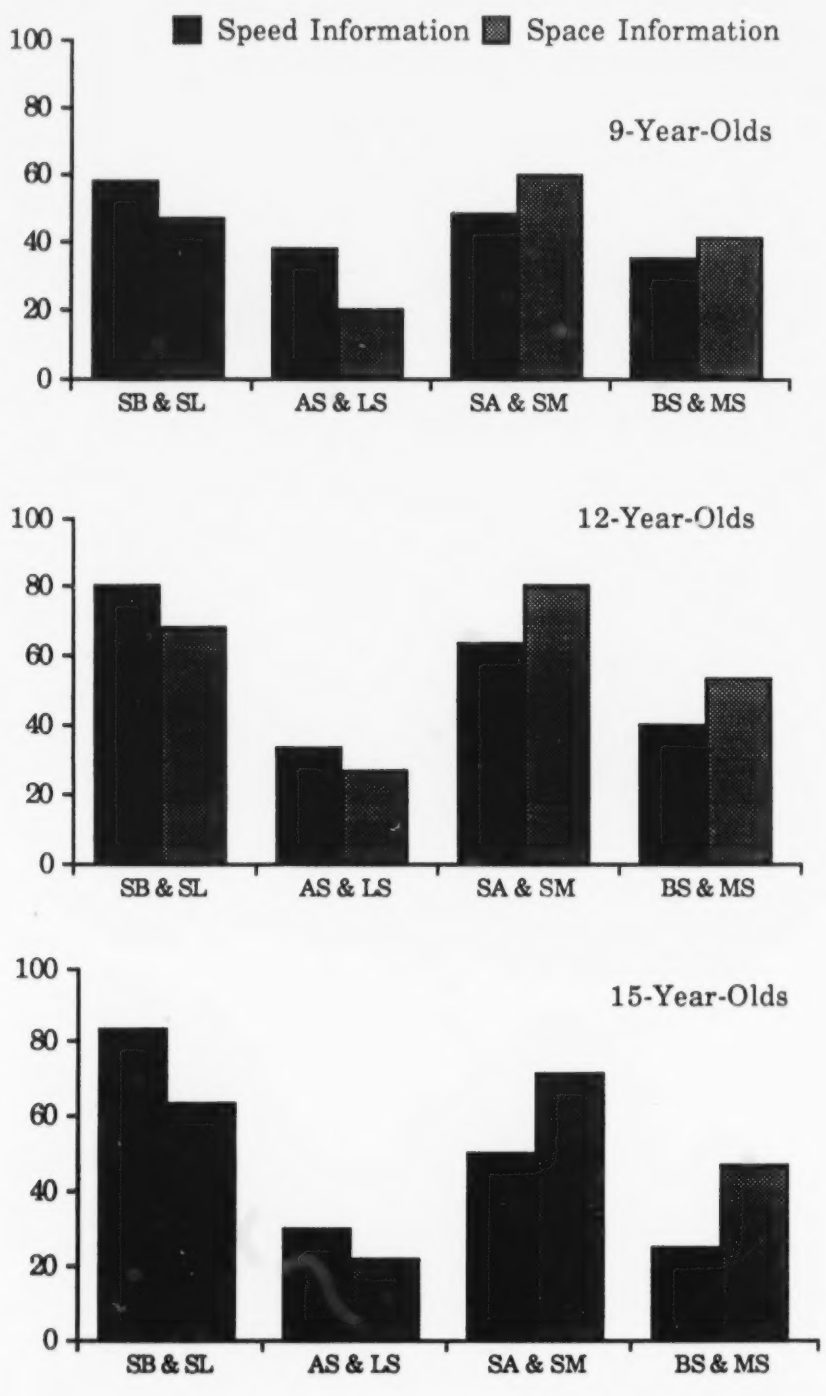


**Figure 1. Effect of Speed and Space on Mean Percentage Correct Time Responses for Each Age Group.**

One Response Correct

| | Age | | |
|---|---|---|---|
| | 9 | 12 | 15 |
| Speed Responses | | | |
| "More" | **0.542** | **0.642** | **0.692** |
| "Less" | 0.242 | 0.250 | 0.125 |
| "Same" | 0.225 | 0.100 | 0.158 |
| Space Responses | | | |
| "More" | **0.458** | **0.383** | **0.433** |
| "Less" | 0.142 | 0.108 | 0.075 |
| "Same" | 0.400 | 0.500 | 0.334 |

Three Responses Correct

| | Age | | |
|---|---|---|---|
| | 9 | 12 | 15 |
| Speed Responses | | | |
| "More" | 0.483 | 0.317 | 0.433 |
| "Less" | 0.283 | 0.533 | 0.275 |
| "Same" | 0.233 | 0.150 | 0.250 |
| Space Responses | | | |
| "More" | 0.475 | 0.133 | 0.283 |
| "Less" | 0.192 | 0.217 | 0.167 |
| "Same" | 0.333 | 0.642 | 0.492 |

Note. The numbers in bold represent the correct answers.

Table 2. Mean Proportions of Speed and Space Responses as a Function of Age and Problem Type.

## Conclusions

Preadolescents and adolescents have difficulty solving problems about time when these problems are presented in a written format. Furthermore, the inclusion of irrelevant speed and space information may hinder performance.

Specifically, the solutions involving the direct relation *faster - more time* or the inverse relation *farther - less time* are particularly difficult for all age groups. These findings suggest that participants try to incorporate the space and speed information when making time judgments.

Contrary to expectation, the concepts of speed and of space do not have the same status. Solving speed problems is easier than solving space problems. In addition, the patterns of errors are not the same for both dimensions. Nevertheless, all age groups seldom recognized the three possible answers for either the speed or the space problems.

Results support the notion that specific relations exist between the concepts of time, speed and space. Time judgments may be hindered if these relations conflict.